

Review Article

Functional Tests and Their Reliability for Return to Sport After Shoulder Injuries: A Review Study



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ABSTRACT

Background: Understanding the relationships between exercise and performance tests is crucial for the sports rehabilitation expert.

Objectives: To comprehensively review functional tests and their reliability for return to sport (RTS) after shoulder injuries.

Methods: During this research, a comprehensive review of the functional tests for RTS after shoulder injuries was performed by searching the Web of Science, PEDro, Google Scholar, PubMed, ScienceDirect, SCOPUS, and CINAHL databases with the keywords shoulder RTS, return to play, upper limb and shoulder functional tests from 2000 to June 2021. English was used in this search. After gathering the research results, first, the titles and then the summary of the research papers were studied. If the research papers meet the inclusion and exclusion criteria, their results will be utilized in the study of review otherwise they will be excluded.

Results: When searching the texts, 123 research papers were found, after deleting 11 identical titles, 112 abstracts were chosen for review. After analyzing the abstracts, 79 research papers were removed and 33 research papers were selected for full study. After reviewing the full-text research papers, 21 research papers were removed and 12 research papers were selected from among the research papers that were very closely related to the subject under study. Many functional tests exist, but few have been studied to evaluate the RTS after a shoulder injury.

Conclusion: Functional tests can assist in estimating when an athlete will RTS or exercise without restrictions. Therefore, according to the results of the current research, functional tests can be an effective tool to assess RTS after shoulder injuries, but due to the limitations and lack of information in this area, further studies are required to be conducted. Therefore, caution should be taken and a general rule should not be drawn for all shoulder injuries.

Keywords:

Return to sport,
Functional tests, Shoulder
injuries, Upper limb

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1. Introduction

Injured athletes seeking to return to sport (RTS) or exercise to previous levels before shoulder injury have to recapture muscle vigor, dynamic stability, and shoulder function [1]. Nevertheless, due to the dearth of evidence-based criteria to precisely evaluate the glenohumeral joint dynamic stability [2], clinical doctors utilize associated evaluations, such as function and strength to ascertain preparedness for RTS [3-7]. In addition, it is unlikely that any test method can demonstrate dynamic stability. Therefore, the use of objective and clinical testing etiquettes is vital to direct RTS after shoulder traumas [8]. Determining the timing of RTS after shoulder damage and the dearth of reliable and valid tests is a major problem for clinicians [9, 10]. Professional athletes who are away from sports for a long time due to shoulder injuries, it can jeopardize their career opportunities [11]. Moreover, the recurrence rate of shoulder instability after a dislocation of the shoulder can be higher than 50% with both non-surgical and surgical therapy being successful [12, 13]. In another study, the reoccurrence rate of dislocation was 40% in patients younger than 20 years, and 63% in 20 to 40 years [14, 15]. It shows that improvement in decision-making for RTS after shoulder injury is essential and a crucial step to facilitate decision-making is to create physical performance tests [16]. Wilson et al. [17] designed a practical etiquette to evaluate readiness for RTS. The etiquette used isokinetic external and internal strength, two functional evaluations, lateral rotation endurance testing, the unilateral seated shot-put test, and the closed kinetic chain upper extremity stability test (CKCUEST). This etiquette showed remarkable deficiencies in people who wanted RTS after six months of shoulder stabilization [17]. While this etiquette is vital in deciding to RTS, it has limitations that should be considered. First, this etiquette uses an isokinetic strength test, which is a time-intensive and costly test and is not commonly used in many clinical environments [18]. Even though isokinetic evaluation is the standard criteria to evaluate shoulder strength [19, 20], isometric testing through manual dynamometry is an alternative method that is more feasible to be performed by clinicians. The second one is the psychometric properties, especially the reliability and validity [21]. Physical performance tests should be uncomplicated, inexpensive, and applicable in clinics [22, 23]. In clinical trials, attention should be paid to the sport to which the athlete wants to return because many variations exist in the requests of various sports [24]. Moreover, despite most sports requiring athletes to exercise for a prolonged duration of time, contem-

porary physical performance tests announce secluded efforts [25-28] and do not determine toleration ability. Therefore, a one-time test may not precisely estimate the preparedness of an athlete for RTS for the required period, meaningful performance tests that inspect tolerance are needed [16]. Eventually, tests that measure only one construct have limited clinical utility. Therefore, tests that measure all the various constructs, such as strength, range of motion, power, and neuromuscular control may enhance the capability to ascertain a secure RTS (Figure 1) manifests the necessary constituents of the functional test). Therefore, it is essential to design a group of secure, valid, and reliable physical performance tests. Considering that few review studies have been conducted in this field, therefore, the main motive of this review research is to survey and announce the functional tests for RTS after shoulder injuries. Hope that the results of this research will supply guidance for the optimum method of testing in the clinic-based applications and return to the decision-making of sports.

Objectives

A comprehensive review of the functional tests and their reliability for RTS later than injuries of shoulders.

2. Methods

This is a systematic review developed according to the preferred reporting items for systematic reviews and meta-analysis (PRISMA).

Search strategy

In the present research, a comprehensive review of the functional tests for RTS after shoulder injuries were conducted by searching the Web of Science, PEDro, Google Scholar, PubMed, ScienceDirect, SCOPUS, and CINAHL databases with the keywords using three groups of search terms, (group 1) “shoulder return to sport” or “return to play” or “return to competition” or “return to activities” or “return to participation”, and (group 2) “upper limb” or “upper body” or “upper limb” or “shoulder complex”, and (group 3) “shoulder functional tests” or “shoulder functional battery tests” or “shoulder functional assessment” or “shoulder functional evaluation”. These combinations (of three groups) were investigated in keywords, titles, and abstracts of the research published by the indexed journals in the databases that were performed from 2000 to June 2021. Also, a manual search and comprehensive review of research paper sources was conducted to find research papers that cannot be found through electronic search.

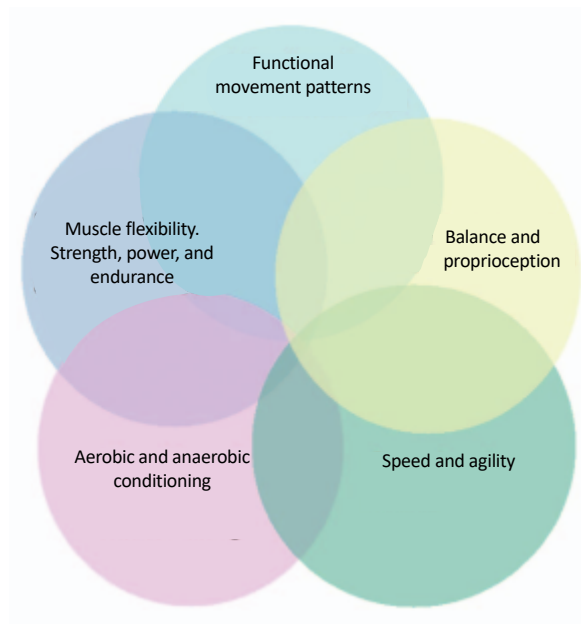


Figure 1. The necessary elements of functional testing [29]

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Eligibility criteria

The inclusion criteria included athletes or people who underwent rehabilitation programs, and suffered shoulder injuries, such as anterior and posterior instability, dislocations, ruptured rotator cuffs, and use of functional tests to RTS. English-language research papers, full-text studies as well as studies which were randomized control trials, cross-sectional, and cohort designs were published. The exclusion criteria included other shoulder injuries, such as fractures of the proximal arm, and research papers that were published briefly in congresses and seminars.

Study selection

The English language was used in this search. All texts were screened by researchers. Finally, using relevant keywords, 123 research papers were received from da-

tabases. At first, the titles of the research papers were examined and 11 duplicate research papers were removed. In the next step, abstracts of 112 research papers were examined, and then 79 research papers were excluded from the study due to non-compliance with the inclusion criteria. In the following, 33 research papers were studied in full text, and after that 21 research papers were removed due to non-compliance with the inclusion criteria (for example, not being in English, not using performance tests for RTS after shoulder injuries, etc.). Finally, 12 research papers were contained in the present review and their results were reported fully. Another senior researcher checked the final list of selected research papers to ensure that all research papers were consistent with the objective of the study. [Figure 2](#) shows the study selection procedure. The population, intervention, comparison, outcomes, and study (PICOS)-type framework is based on the research inquiry stated ([Table 1](#)).

Table 1. Population, intervention, comparison, outcomes, and study (PICOS) framework

Framework Components	Description
Population	Athletes or people with shoulder injuries such as instability, dislocation, and rotator cuff tears.
Intervention	Performing functional tests to measure readiness for RTS after shoulder injuries
Comparison	A detailed report of the research included in the current study and then compared the results of the studies to determine which functional tests are used to determine the readiness for RTS after shoulder injuries.
Outcome	The main objective of this review was to diagnose the available functional tests for RTS after shoulder injuries.
Study type	Studies which were randomized control trial, cross-sectional, and cohort designs.

Abbreviations: RTS: return to sport

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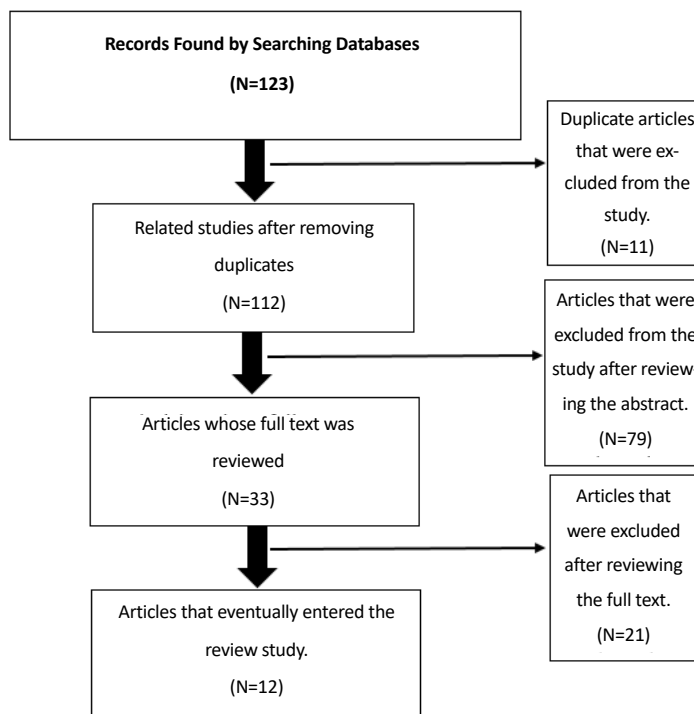


Figure 2. How to select research papers in this study

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3. Results

A search of [Web of Science](#), [PEDro](#), [Google Scholar](#), [PubMed](#), [ScienceDirect](#), [Scopus](#), and [CINAHL](#) databases found 123 research papers. After eliminating 11 identical titles, 112 abstracts were selected for review. Then the abstracts were reviewed, 79 research papers were removed and 33 research papers were selected for full-text reading. After reviewing the full-text research papers, 21 research papers were eliminated and 12 research papers were included in the study. The following are the necessary criteria to enter the stage of performing functional tests for RTS ([Table 2](#)).

The Results of Research Examining Functional Tests for Returning to Sport (RTS) After Shoulder Injuries

Popchak et al. studied the validity and reliability of RTS testing for the shoulder injury. Thirty healthy active adults with an average age of 24.0 ± 1.6 years participated in this study. Total functional assessments (intraclass correlation coefficient [ICC]: 0.80-0.92), isometric (ICC: 0.83-0.94), and isokinetic (ICC: 0.88-0.94) had fine to very good intra-rater reliability, considering the repetition to failure testing had low to average reliability (ICC: 0.48-0.57). The results of this study also showed that the isometric, isokinetic, and functional evaluations in this testing procedure show admissible reliability and validity [8]. Pontillo et al. studied the use of an upper limb

Table 2. Criteria for progression to functional testing phase to access return to sport (RTS) [30].

Full, pain-free shoulder ROM without substitutional patterns
No shoulder instability
Pain-free exercises
Proper scapular posture with rest and dynamic scapular control with ROM and strengthening exercises
Good strength in all planes of motion (Muscular strength of 75% to 80% of contralateral side)
Satisfactory scores on shoulder activity scores

Abbreviations: RTS: return to sport; ROM: range of motion

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Table 3. A list of recommended upper limb tests for use after micro- and macro-trauma (with some clearance criteria for return to sport [RTS]) [7]

<p>Upper Limb Tests for the Overhead Athlete (Microtrauma)</p>	<ul style="list-style-type: none"> • Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow Score • Range of Motion: Full. non-painful PROM • Isokinetic Testing: External rotator peak torque/body weight ratio @180°/sec: 18%-23%. Internal rotator peak torque/body weight ratio@ 180°/sec: 26%-32%. External rotation/internal rotation (ER/IR) ratios@180°/sec: 72%-76%. Bilateral comparison: ER 95%-100%, IR 100%-110%. No pain or apprehension during the test. • Ball Drop Test: 100% involved to uninvolved • Wall throws 90/90° test • Functional throwing performance index • Single leg step-down test • Underkoffler overhand softball throw for distance
<p>Upper limb Tests After Macrotrauma</p>	<ul style="list-style-type: none"> • Western Ontario Shoulder Instability Index(WOSI): Shoulder Score of ≥ 95 • Range of Motion: Full. non-painful PROM • Isokinetic Testing: External rotator peak torque/body weight ratio @180°/sec: 18%-23%. Internal rotator peak torque/body weight ratio@ 180°/sec: 26-32%. External rotation/internal rotation (ER/IR) ratios@180°/sec: 72%-76%. Bilateral comparison: ER 95%-100%, IR 100%-110%. No pain or apprehension during the test. • Push-up Test: Ability to perform more repetitions in the second testing bout • Pull-up test modified pull-up test • Flexed arm hang • Medicine ball tests • CKCUEST: ≥ 25 repetitions • One Repetition Maximum Bench Press Test: $\geq 95\%$ of pre-injury 1 repetition maximum (1RM) without substitution • Unilateral Maximum Chest Press Test • Unilateral Pulling Assessment: ($> 100\%$ limb symmetry index) • Single Arm Pushing Assessment: ($> 100\%$ limb symmetry index) • Upper quadrant Y-balance test • Single arm seated shot put test

Abbreviations: CKCUEST: closed kinetic chain upper extremity stability test; PROM: passive range of motion; ER: External rotator; IR: internal rotator

Table 4. Shoulder arm return to sport (RTS) test battery

Open Chain Tests	Closed Chain Tests
Ball abduction external rotation	Push-up claps
Drop catches	Line hops
Ball taps	Side hold rotations
Overhead snatch	Modified CKCUEST

Abbreviations: CKCUEST: closed kinetic chain upper extremity stability test

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functional testing algorithm to calculate returning-to-play preparedness in collegiate soccer players. Six participants (18 to 21 years old) who experienced shoulder capsulolabral mend participated in this research. Functional tests used in this study included standing cable press, performed at 30% body weight (BW), Scaption, performed at 5% BW, Prone-y, performed at 3% BW and CKCUEST. In this study, it was shown that the upper limb functional testing algorithm assists in evaluating RTS in male collegiate athletes of soccer [31]. Wilk et al. studied the RTS criteria for injury of shoulder: A clinic-based report. In this study, Wilk presented the functional battery tests for RTS after shoulder injuries, which can

be seen in Table 3. The results of this research demonstrated many functional tests, but different tests can be used depending on the type of injury [7].

Hollstadt et al. studied the reliability of test-retest of the CKCUEST in an adjusted test place in dividing I collegiate basketball players. The results of this study showed that the CKCUEST in an adjusted test place is a reliable evaluation device and underpins preceding discoveries [32]. Decleve et al. studied the “upper limb rotation test”, a validity and reliability investigation of an up-to-date upper limb physical performance test. Results showed good reliability. A moderate correlation

Table 5. Reliability of functional tests

Functional Test	Researcher	ICC	Reliability
CKCUEST	Degot et al. [34]	0.92	Excellent
	Hollstadt et al. [32]	0.90	Good
	Popchak et al. [8]	0.80	Good
ULRT	Decleve et al. [33]	0.80	Good
Modified pull-up	Negrete et al. [37]	0.95	Excellent
	Burnstein et al. [38]	0.88	Good
Timed push-up	Negrete et al. [37]	0.98	Excellent
Single-arm seated shot-put (DA and NDA)	Negrete et al. [37]	0.98	Excellent
Functional throwing performance index	Davies et al. [39]	0.91	Excellent
One repetition maximum bench press	Seo et al. [40]	0.99	Excellent
UQY-B	Westrick et al. [41]	0.91 - 0.92	Excellent
	Gorman et al. [27]	0.80 - 0.99	Good-excellent
Upper extremity hop	Falsone et al. [42]	0.78 – 0.81	Good
Under Koffler softball throw	Collins et al. [43]	0.95	Excellent

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Abbreviations: CKCUEST: closed kinetic chain upper extremity stability test; ULRT: upper limb rotation test; NDA: non-dominant arm; DA: dominant arm; UQY-B: upper quadrant Y-balance test

($r=0.553$) was discovered between the CKCUEST and upper limb rotation test (ULRT) scores. A moderate correlation ($r=0.556$) was found between ULRT and SMBT scores [33]. Wilson et al. built up an objective and functional criterion-based shoulder testing etiquette to assess RTS preparedness in clinic-based environments. The etiquette used was external rotation endurance testing, isokinetic external and internal strength, and two functional evaluations, the CKCUEST and the unilateral seated shot put test. The use of this etiquette disclosed remarkable deficiencies in patients arranging for RTS at six months after shoulder balance. Although this etiquette is essential for RTS decisions, it has limitations that should be noted [17]. Degot et al. studied interrater reliability and consensus of a modified CKCUEST. The results showed that reasonable reliability was discovered for the muscular endurance index calculated while splitting the one-half number of touches computed throughout the final 30s of the one-min set, by the m-CKCUEST score computed above ($ICC=0.86$). The m-CKCUEST allows for the production of two reliable result measurements that estimate muscular endurance and upper limb stability. The aforementioned results may be utilized in the aftermath to evaluate rehabilitation level or performance [34]. Olds et al. investigated the shoulder arm RTS test reliability. Functional tests within this study were divided into two categories, which can be seen in Table 4. The results of this research demonstrated six of the eight tests in the shoulder arm return to sports test show fine psychometric properties to assess both closed and open-chain upper limb activities designating their preparedness for clinical utilization [16].

Borms et al. studied the upper limb functional performance test, reference values for overhead athletes' functional tests used in present research included SMBT, CKCUEST, and upper quarter Y balance test (YBT-UQ). To sum up, this research provides normative data for the upper quarter Y balance test (YBT-UQ), CKCUEST, and seated medicine ball throw, which clinically pertinent for screening overhead athletes in terms of performance and their performance relative to others of the same age, gender, and sports [35]. Chmielewski et al. investigated standardization reflections for utilizing the one-sided seated shot-put test in rehabilitation. The results of this study showed that acquiring these data may ease the use of the one-sided seated shot-put test for RTS decision-making in upper limb rehabilitation. In limb comparison, the dominant side should perform 5% to 10% better, and performance benchmarks should be set based on gender [26]. Manske and Reiman studied functional performance testing for RTS and power. In this study, the seated shot-put throw test was executed. The results of this

study showed functional performance tests can assist in deciding when an athlete can go back to unlimited activity [36]. Negrete et al. investigated minimal detectable change and normative values reliability for tests of upper limb power and function. In this study, a functional seated shot-put test for the nondominant arms and dominant, modified pull-up, and push-up tests were executed. The results of this study showed that returning to daily life activities in full or sports ought to be based on the suitable performance of the whole of the tests in succession. The present research may help in the progress of a serial testing paradigm for use through the training and rehabilitation of patients with upper limb injuries [37].

Reliability of functional tests

Table 5 presents the reliability of the performance tests.

4. Discussion

This review was conducted to assess and identify functional tests and their reliability to RTS after shoulder injuries. The results of this research showed that little research has been conducted in this field and it is a new research field. Thus, after the survey, only 12 studies presented functional tests for RTS after the trauma of the shoulders. However, two of these studies provided a pack of functional tests for RTS after the trauma of the shoulder. In the first study conducted by Olds et al., the reliability of a shoulder arm RTS group test was examined. In this study, the tests were split into two groups of open and closed-chain tests. Each group consisted of 4 tests [16]. In the second study conducted by Wilk et al., the participation criteria of the RTS after injury of the shoulder were examined. In this study, 17 functional tests for RTS after Microtrauma and Macrotrauma shoulder injuries were reported [7]. This study is both more recent and more complete than Olds et al.'s study and also provides a certain amount and numerical range for some functional tests. For example, in the CKCUEST, for an athlete to be allowed to RTS, his record in this test must be ≥ 25 repetitions. This study also divided shoulder injuries into two groups including Microtrauma and Macrotrauma injuries while providing specific functional tests for each group [7]. Also, the results of the study conducted by Popchak et al. demonstrated all isokinetic ($ICC: 0.88-0.94$), functional assessments ($ICC: 0.80-0.92$), and isometric ($ICC: 0.83-0.94$) had fine to very good intrarater reliability, while repetition to failure testing had low to average reliability ($ICC: 0.48-0.57$) [8].

The topic of RTS after a shoulder injury has become vital in the rehabilitation program today because the

athlete should reach the previous level of preparation for RTS. To ascertain if an athlete is prepared for RTS, various tools are used, one of the most practical and inexpensive of which is functional tests, which are recommended for several reasons, these tests are similar to the athlete's movement patterns, these tests have the necessary capabilities to assess the athlete's physical fitness, in addition to the global components of the movement system, these tests also pay attention to the local components of the movement system, the tests are tailored to the needs of the athlete, these tests identify the strengths and weaknesses of movement patterns, these tests are made of inexpensive tools and equipment and can be used in sports environments, and finally, these tests can gauge an athlete's preparedness to RTS [29, 44].

However, the point is that the functional tests used in the studies evaluated some physical factors and ignored the evaluation of some factors. Most tests presented in the studies evaluated the strength, stability, and range of motion of the shoulder. These factors are indeed the main elements of an athlete's mobility, but it can also be crucial to consider some other factors, such as muscle endurance, coordination, and reaction time [29]. Because as much as an athlete needs stability and strength in the shoulder joint, he can also need endurance and coordination of the shoulder joint muscles. To improve the movement pattern and RTS, it is essential to pay attention to all the elements of physical fitness of the upper limbs, especially the shoulder joint. Considering that most of the research conducted in the field of RTS after shoulder injury was conducted from 2018 to 2021. It indicates that a new field of study is ahead and, in the future, it can be expected that new studies will address the issues mentioned and cover the weaknesses of previous studies and more functional tests to the functional battery RTS tests after adding shoulder injuries, the result of which can be the athlete RTS and competition environment as fully as possible.

5. Conclusion

Functional tests can assist in ascertaining when athletes can RTS or exercise without restrictions. However, more research is needed to quantify the tests. In addition, it is essential to convert quantities to standard norms for reference in other studies because little information exists about functional tests to return to activity after an injury of the shoulder. One of the limitations of the present study was that only studies published in English were reviewed, and more extensive research was needed. Therefore, according to the results of the current research, it can be noted that functional tests can be an effective

tool to assess RTS after shoulder injuries, but due to the limitations and shortcomings in this area, it is required to conduct further research, such as normalizing functional tests for RTS and providing a functional battery test for RTS after shoulder injuries. Therefore, caution should be taken and a general rule should not be drawn for all shoulder injuries.

Ethical Considerations

All ethical principles were considered in this article. The participants were informed of the purpose of the research and its implementation stages. They were also assured about the confidentiality of their information and were free to leave the study whenever they wished, and if desired, the research results would be available to them.

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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